What will it Take to Tame the Acid Rain in North America?

The Changing Earth Times

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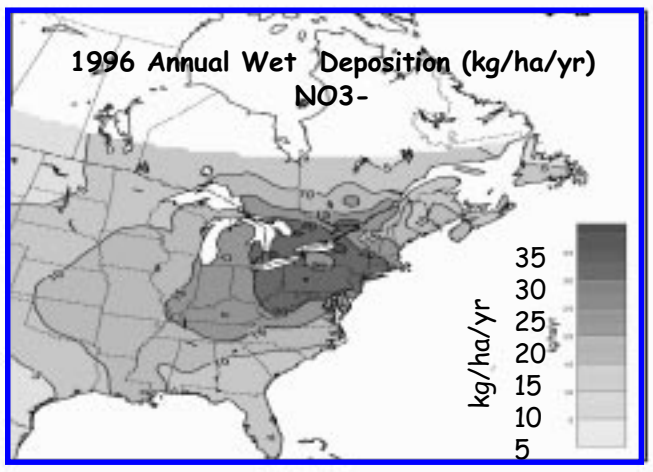
AIR POLLUTION POSES CONTINUING ACID RAIN THREAT

You wake up in the morning by your digital alarm clock. Turning on the lights, yawning, you head to the bathroom for your hot morning shower. Ahh! Awake and refreshed you get dressed to some tunes on your radio and head to the kitchen for a bite to eat. Looking at the clock you realize you're late, grab a toasted bagel and quickly jaunt to the bus stop. You jump on the bus or in your car and enjoy a bumpy half hour ride.

We all do these daily energy consuming tasks whether we go to school or work. So what's the big deal? It's the effect of our energy use polluting the environment that's a problem. Scientists report that fossil fuel burning for our electricity and transportation needs emit NOx (nitrogen oxides), a pollutant that is becoming a threat to our forests and inland waters. Ironically, while nitrogen is a vital nutrient, it is now also considered one of the major contributors to acid rain (acidic deposition).

It seems that as NOx pollution falls from the sky, it results in too much nitrogen, or nitrogen saturation of the soil. As levels increase, evidence is mounting that our forests are being stressed and could likely change to vegetation types that can better tolerate such conditions. As nitrogen travels through the groundwater into lakes and ponds, existing fish and aquatic life become altered as well, limiting the species of fish that can survive there.



The authors gratefully acknowledge the Canadian National Atmospheric Chemistry (NAtChem) Database and its data contributing agencies/organizations for use of this map.

What will it take to tame the beast of the east? Scientists have been monitoring water quality as an early warning of ecosystem response. So, a main goal of the 1990 Clean Air Act Amendments (CAAA) was to decrease acidity of surface waters by reducing sulfate pollution. As a result of the emission reductions, scientists have measured a step towards recovery in sulfate levels, but only a small response in the acidity levels of sensitive lakes. Evidence now suggests NOx is the major pollutant preventing full recovery of surface waters. Scientists from the Conference of New England Governors and Eastern Canadian Premiers (NEG/ECP) water monitoring workgroup are calling for more emission reductions to prevent acidification of lakes and ponds.

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Attention Middle School & High School Teachers!

Introducing the Earth Times

The Changing Earth Times is an environmental studies news bulletin with activities for middle and high school students. It is a teaching tool to bring the latest science research into the classroom.

In this issue: What are the causes of acid rain? What will be theimpacts on earth's ecosystems? Students will explore these questions through a role-playing activity, virtual research activities and a risk management activity. The decisions students make involve economic, social, political and environmental considerations. This content aligns with U.S. National Learning Standards for scientific inquiry, nutrient cycling and scientific communications skills.

This issue of the news bulletin was developed with the Conference of New England Governors and Eastern Canadian Premiers (NEG/ECP), a governmental group working to decrease acid deposition. It was developed by AmeriCorps Educator JoAnna Greenwood and Maine DEP's Deb Avalone-King. Visit <http://janus.state.me.us/dep/air/outreach.htm> to learn how to obtain additional copies.

Informational Websites

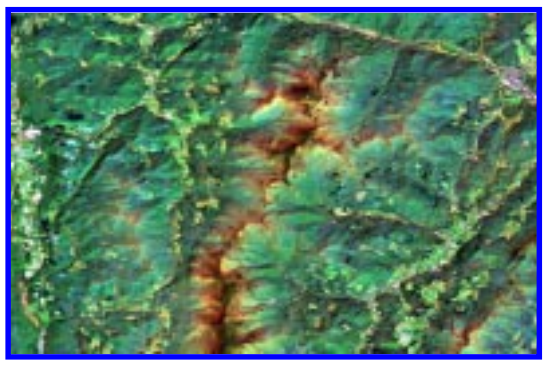
http://www.epa.gov/acidrain/student/student2.html
http://esa.sdsc.edu/tillan.htm
www.ec.gc.ca/acidrain/index.html
http://airquality.tor.ec.gc.ca/natchem
http://nadp.sws.uiuc.edu
www.cals.cornell.edu/dept/flori/growon/nitrogen.html
www.geog.ouc.bc.ca/physgeog/contents/9s.html

IS ACID DEPOSITION A CONCERN IN YOUR STATE OR PROVINCE?

Virtual Research Activities

A) Analyzing Scientific Data: In groups of 2-4 students, choose a state or province of interest to research and analyze acid deposition data. Use either the **nadp** or **NatChem** websites. By visiting Canadian and North American websites, your students can access scientific monitoring data for their own region, record and graph the data and analyze the results by comparing and contrasting the data. For instructions visit <http://janus.state.me.us/dep/air/outreach.htm>.

B) Conducting an Inquiry Based Scientific Research Project: Examining acid precipitation in the context of understanding the scientific method. Students will be challenged to make preliminary observations, formulate questions and hypotheses as well as make predictions and test their results. Visit internet <http://heg-chool.awl.com/bc/companion/cmr2e/activity/AP/APPre01.htm> for instructions.



This enhanced satellite image of the Green Mountains in Vermont depicts fir/spruce forests above 3,000 feet that have been stressed by acid fog deposition. *Source: Gary Lauten, Research Scientist, UNH.*

HOW ARE SCIENTISTS DETERMINING HOW MUCH NITROGEN IS TOO MUCH?

Field Research Report

Since 1987, Maine scientists have been measuring water flows and collecting data on soils and vegetation on the steep mountainside of Lead Mountain in Hancock County. The study, known as the Bear Brook Watershed Manipulation Project, involves spreading granular ammonium sulfate in West Bear Brook directly onto soil and vegetation 6 times a year, leaving the East Bear Brook untreated. Researchers want to better understand the process of acidifcation and the geo-chemical data will provide policy makers with data to develop strategies for future ecosystem management.

Studies still continue on this 54 acre watershed as researchers attempt to model the nitrogen cycle; to unlock the connection between nitrogen and changes in forest ecosystem processes and water quality. To learn more, visit: internet site <http://www.umaine.edu/mainesci/Archives/GeoSciences/BearBrook.htm>.

MAKING DECISIONS ABOUT ACID RAIN RISKS

Risk is the probability or likelihood that a harmful consequence will occur as a result of an action or exposure. You and I make decisions about risk everyday, in choosing what we eat, how we travel, what we do with our money, in all our lifestyle choices. But there are many things we do not get to make choices about, like exposure to air pollution and its effect on our ecosystems or our health.

Environmental Risk managers are often faced with multiple risks that require attention. The resources for managing risks are usually limited and we are often faced with hard decisions about where money will be most effectively spent. So how do we do that? The way we think about a risk is based on our values and our psychological, socioeconomic and cultural background. People's notion of what is ethical or acceptable can vary greatly.

Risk professionals attempt to prevent risks to public health, safety and the environment by creating risk assessment and management techniques. Health risk experts measure risk in terms of the risk of developing cancer from exposure to certain chemicals. For example, you may have a 1 in 10,000 chance of getting cancer, or a 1 in 1,000,000 chance of getting cancer from exposure to pollutants. How much cancer risk is okay for you?

Economists on the other hand, use a cost/benefit approach for analyzing risk. For example, in one study by economists at Resources for the Future, the benefits for acid rain emission reductions, included reduced exposure to sulfates and other pollutants. For **health risk**, the economists estimated the impacts of air pollution levels on human health. They calculated the potential number of days of acute morbidity (short illness), the number of chronic (long term) disease cases and the number of premature deaths. How much disease would you find acceptable?

Acid rain's effect on **ecosystems** include reduced visibility of our national park vistas, and changes in lake and soil chemistry. Such characteristics are difficult to put a value on. Economists were, however, able to put a monetary value on improved recreational fishing and the avoided cost of neutralizing acidic lakes with lime. Thus they decided that the 1990 CAAA reductions, which cost an average of $6/person, were a reasonable expense.

Create an "Acid Rain" TV Special

Please note: If video equipment is unavailable or as interest directs, students could develop an electronic presentation.

In this class role-playing activity, you will play a major role in producing a special segment series for a TV program. Using video-recording equipment your class or team will depict the effects of weather patterns on the travel of acid rain over large distances and its consequences in a forested ecosystem. You will be given time to research your role and the information needed to make a TV segment. It is suggested that 3 segments be conducted as part of a mini-series. One could pertain to introducing the problem of acid rain and where it comes from; the second to weather patterns and the travel of rain and air pollution over large distances; and the third could deal with the social, political and environmental consequences of acid rain as well as recommendations for public behavior changes that could help address the problem.

Your class can be broken down into three teams each working on one of the segments. The roles within the teams are as follows, as well as any other role you or your teacher finds appropriate. You may find that each team member will play more than one role during this activity.

TV Reporters: Like Connie Chung or Peter Mansbridge, you are responsible for effectively presenting the material in a professional manner via TV. Your duties will vary and you will work with all members of your team.

Producers/Directors: Your role involves working very closely with all the crew members. You will provide direction for the crew by helping generate creative ideas and making sure that each job gets done. It is important for you to have a clear vision of what your team is trying to accomplish and to make sure the job gets done.

Camera/Computer People: You will be responsible for filming and working with all of the other crew members to produce a quality series.

Lights and Stage/Graphics Consultant: You are responsible for all the lighting and stage setup and background props. You will work closely with the camera people and the writers, directors and reporters to effectively portray the assignment.

Writers: Your role is to write the script by closely working with the reporters, scientists, directors and producers. The final written outcome will flow and accurately relate the science of acid deposition in an understandable manner.

Scientist(s): Your role is to provide the scientific background on weather patterns and acid rain to the crew members.

Evaluation Guidelines:

1) Did your team effectively depict the effects of weather patterns on the transport of air pollution over large distances and its impact on forested ecosystems?
2) Did your team effectively portray the social, political, and environmental consequences of acid deposition?
3) How well did your group meet the organizational challenges of producing a video series or electronic presentation?

Environmental Risk Management
Virtual Research & Decision-Making Activity

Using the Maine Environmental Priorities Project, an example of an effort to develop a public consensus ranking of environmental risks, you will examine the risks we face from environmental problems and emerging issues of concern. The report can be accessed on the internet at http://www.state.me.us/dep/mepc/ .

The environmental risks of concern as ranked by this organization are:

drinking water and domestic use water	indoor air
freshwater and marine ecosystems	outdoor air
surface Water and sediments	terrestrial ecosystems
global climate change	agricultural resources
solid, special and hazardous waste	radiation (not radon)
stratospheric ozone depletion	ground water

1) **Preparatory Research:** Review the technical support documents on the web site. Divide up the work between members of your group. **Research Tips:** Take notes on the issues and indicators cited in the general description. What are the risks identified by the researchers. Do any risks include health impacts? What values and judgements (scientific and unscientific) did the researchers identify as public concerns? Did they cite any cost/benefits of managing the risks?

2) **In Class:** In small groups, discuss and rank the risks for the topics listed above into high, medium, and low categories. Did your group members agree or disagree with the MEPP ranking? (Rec. time: 30 minutes)

3) **In Class:** As a whole class, share your results, and discuss the variety of reasons for rankings. What values, scientific and non-scientific judgements, were used to rank the risks? What level of concern should we care about in health risk assessment? (eg. Whether cancer occurs in 1/10,000 or 1/1,000,000 people?) Does cost/benefit analysis provide a reliable means for deciding whether we should implement a pollution solution? (Rec. time: 30 minutes)

4) **In Class:** Now ask each individual to choose their own top "3" risks. Sum up the findings and see which risks most concern your class. What are the top 3 concerns?

Reflection/Assessment Questions:
Consider the ways everyone made decisions about these risks. Did people accept what you told them? Was anyone influenced by the way others reacted? Was anyone outraged about a particular issue? Why? Did people feel they had the ability to do something about the risks? All of these reactions are common reactions as we perceive risks day to day. How can we learn to evaluate information, data and warnings presented by the media or government? How can we present information to others in a way that will engage them in discussion and then encourage them to take action and make a difference?

Note for Teachers: An excellent resource guide with general risk assessment/management curriculum activities is the *Project Learning Tree Guide, Exploring Environmental Issues: Focus on Risk.*

Acid Rain/Nitrogen Effects on Ecosystem continued...

How does N saturation effect an ecosystem?
In unpolluted conditions, Nitrogen is mostly retained in soils by plants and micro-organisms. Nitrogen saturation occurs when the supply of nitrogen compounds from total deposition exceeds the amount plants and micro-organisms can use. It is dependent on total deposition, land use, vegetation cover, forest stand age and soil type as well as other factors. This process can also be strongly influenced by climate change, global warming and atmospheric CO_2 (carbon dioxide) and O_3 (ozone).

Nitrogen saturation affects soil chemistry, nutrient availability, leaf and forest productivity. Eventually nitrates leach into surface waters or percolate into deeper soil layers reaching groundwaters. In coastal waters where N is usually limited, it can cause eutrophication, a process where increased algae growth and organic matter accumulate in estuaries. Not only does this alter important breeding areas of marine organisms and fish, but it can also increase the frequency of harmful algal blooms creating low oxygen conditions that stress or kill off shellfish populations.

How much N should we be concerned about?
The NEG/ECP researchers view Nitrogen saturation as a threat to surface waters in areas receiving annual NO_3 (nitrate) deposition exceeding 10-15 kg NO_3/ hectare/year. Such areas span a wide territory in sourthern Ontario and Southwestern Quebec. On the whole, North American sites are still capable of retaining most incoming nitrogen from deposition, while areas in high elevation with coniferous forest types showing the first signs of nitrogen saturation conditions.

Although the risk to Eastern North America is not an imminent threat, over the next 25-200 years N may become a major problem resulting in a doubling of acidified lakes, an increase in eutrophication and a decline in forest productivity. The good news is, it seems that a deposition rate of less than 8-10kg/NO_3/ha/year may prevent the process of saturation. The bad news is that Nitrogen deposition in parts of SE Canada and New England now ranges between 10 to 25 kg/NO_3/ha/year. The estimated reduction in Nitrogen emissions needed may be as high as 33 to 60%.

How can we avoid or reduce the effects our fossil fuel lifestyle is having on these ecosystems?
Forest management strategies may reduce some risk of nitrogen saturation and runoff. Planting vegetation buffers to trap runoff might reduce impacts on our lakes and ponds. However, we must proceed with caution because some mitigation approaches could enhance other environmental problems. But clearly we would see greater improvements by reducing our use of fossil fuels required to produce electricity and drive cars.

But that's not so easy. Emission reductions can be controversial and many require lifestyle changes. We can reduce emissions from power plants by using less energy. We can drive fewer miles, carpool, or move closer to work. We face a ecological situation that challenges us all to learn more about air pollution effects on our ecosystems and to find ways to reduce our own energy use. What strategies do you think will work best?